REMARKS

Claims 1-14 remain pending in this application. Claims 1-14 are rejected. Claims 1 and 6 are objected to. Claims 1, 6, 9 and 10 are amended herein to clarify the invention.

CLAIM OBJECTIONS

The claims 1 and 6are objected to due to informalities including typographic errors. The claims are amended to address the informalities. Accordingly withdrawal of the objections is respectfully requested.

CLAIM REJECTIONS UNDER 35 U.S.C. §103(a)

Claims 1-6, 9 and 10 are rejected as obvious over the McDowell reference under 35 U.S.C. §103(a). The applicant herein respectfully traverses this rejection. For a rejection under 35 U.S.C. §103(a) to be sustained, the differences between the features of the combined references and the present invention must be obvious to one skilled in the art.

In view of the present rejection being based on the previously applied and discussed McDowell reference, it appears that the present invention as claimed is not fully appreciated as it is quite distinct from the process set forth in the McDowell

reference. Briefly, review of the present invention and what is disclosed in the background section of the present invention disclosure, is a necessary starting point in order to appreciate the present invention. The introduction of the specification describes what a PIV method is and what a stereo PIV method is. The PIV and stereo PIV methods are distinguished from one another in that in the PIV method the camera is oriented on one illuminated section, while in the stereo PIV method, the illuminated section can be observed with at least two cameras from two different angles, and thus all three components of the velocity field can be determined. That is, the reason for the stereo PIV method is to measure two- and three-dimensional velocity fields.

Before measurements of a velocity field using a PIV, stereo PIV, or even 3D PTV method can be effected, a calibration must first take place, i.e., the position of the cameras relative to the plane of the illuminated section is determined, which is ultimately obtained by establishing the imaging equation. The imaging equation can be established using a so-called "calibration plate", and knowing the absolute position in space of the two cameras or using the calibration plate, the angle, and the orientation of the cameras relative to said calibration plate and the spacing between the cameras and the calibration plate, or using a calibration plate that is captured by the cameras in two or more positions. Moreover, there is also a so-called "three-dimensional calibration plate" for determining the imaging equation, such a three-

dimensional calibration plate having two planes with corresponding markings at a fixed distance.

Thc Examiner apparently believes that the claimed invention can be arrived at from the disclosure of the McDowell reference. Applicant respectfully submits that is absolutely not possible based on the McDowell reference. While McDowell performs a calibration step before conducting a 3DPTV mcthod, this is done exclusively with the aid of a calibration plate. The subject matter of the invention, however, is such that, before conducting a stereo-PIV method, in a first step, a rough calibration is performed with the aid of a calibration plate, as is known from the state of the art, and as is ultimately also described in McDowell. This is reflected in claim 1 by the following recitation:

> performing a volume calibration using a calibration plate on said first and second cameras to obtain internal and external imaging parameters[.]

Subsequently, according to the present invention, before conducting the actual PIV method, another calibration is performed, referred to as the "self-calibration", which ultimately consists of the determination of the imaging equation.

The difference between the 3DPTV method and the stereo-PIV method is as follows:

> 3DPTV (particle tracking velocimetry) allows the movement of particles in a space or volume to be determined.

In the stereo-PIV method (particle image velocimetry), the movement of particles in a light section is determined, the light section being viewed through two cameras arranged at an angle to each other.

The explanations above are addressed in detail below.

The present invention provides both the self-calibration by determining the imaging equation, which is not apparent from the McDowell reference, and also the use of the imaging equation in providing a stereo PIV. The self-calibration process is a preliminary stage performed prior to performance of the actual stereo-PIV process in order to increase the accuracy of the stereo-PIV method. In order to clarify this, claim 1 is now directed to a method for performing stereo-PIV for visualized flows which includes both the novel self-calibration process and performance of the stereo PIV using the imaging equation obtained by the self-calibration process. The claim amendments are supported by the original specification on page 5 and also pages 7 and 8. It is believed that this claim format will make clearer the distinction of the present invention.

It is apparent from the Response to Arguments that there exists a basic misunderstanding of the technology at hand. The Examiner cites the McDowell reference at column 6, lines 39 to 65, as well as page 7, line 65, and states that this passage reportedly discloses the formation of the imaging equation by cross-correlation for the purpose of the calibration. In particular, the Examiner states:

> However, McDowell teaches in col. 6, lines 39-65 that point correspondences between the two cameras are calculated from the two-dimensional camera views (interrogation fields). Each individual camera has its own coordinate system ($+X_I$, $+Y_I$, $+Z_I$) for the first camera and ($+Z_2$, $+X_2$, $+Y_2$) for the second camera. The relationship (point correspondences) between the two camera coordinate systems must be determined to correlate the two-dimensional camera determined measurements to real, three-dimensional positions in an absolute coordinate system (+Xw,+Yw, +Zw). McDowell discloses the method in which this optical correlation is determined in col. 6, line 66 to col. 7, line 65.

It appears that the Examiner believes that the above supports "determining the point correspondences between two cameras by measuring the displacement of the interrogation fields in the camera images by means of optical cross-correlation." This speculation appears to be based on the assumption that such an interpretation is substantiated simply by the following recitation in the McDowell reference:

> Since the two cameras 18, 20 are oriented imprecisely with respect to the world coordinate system X_W, Y_W, Z_W, the relationship between the three coordinate systems needs to be determined in order to *correlate* the two-dimensional camera determined measurements to real, three-dimensional positions.

(Emphasis added) Column 6, line 50 to line 55. At this point, it shall be pointed out that the term "correlate" used in the Mc Dowell reference has nothing to do with "cross-correlation". Rather, it is apparent from the content of the description in column 6 to column 7 that what is described here is how to determine the points xi, yi, zi in Fig. 3 by means of triangulation. The fact that the determination of point 56 as a point of intersection of the two rays of light 46 and 54 by way of

triangulation is actually described here is particularly apparent from the description in column 7, from line 13 to 45. The fact that a rough calibration by means of a calibration plate is performed by way of triangulation, is explicitly disclosed in detail in column 7, starting on line 55, which reads as follows:

> The preferred approach is to determine the camera calibration parameter reliably by imaging a calibration target plane containing calibration points.

"A calibration target plane containing calibration points" is nothing other than a calibration plate with calibration points! When, in this connection, the examiner refers to column 8, which describes the individual steps of the calibration process, it is also apparent that reference is made to a calibration plate, specifically since the following is already disclosed for "Step 1":

> Choose the positions of a number (n) reference points in space (absolute coordinates).

"Absolute coordinates" are only obtained when using a calibration plate. This means that McDowell does not teach calibration by the formation of an imaging equation, which requires cross-correlation, but rather the calibration according to McDowell is performed by taking points into consideration, which are determined by absolute coordinates in a space, and which can only be detected if a calibration plate is used

that has calibrating points, as was already demonstrated above based on the explanations according to McDowell in column 7, starting on line 55.

Claim 1 as presently amended requires first the volume calibration using the calibration plate and that images be taken of flow particles in addition to the following procedures:

> determining corresponding correlating ones of said interrogation areas respectively in the first image and the second image such that at least first and second corresponding correlating interrogation areas respectively of said first and second images are identified;
>
> measuring a respective displacement of said first and second corresponding correlating interrogation areas in the first and second images using optical cross-correlation in order to determine the imaging equation;
>
> determining point correspondences of the first and second cameras based on the measured respective displacement; and
>
> determining the imaging equation, including the imaging function M, for the first and second cameras by means of an approximation method, using known internal and external camera parameters and the point correspondences and the displacement of respective interrogation areas.

From the claim wording it is clear that the camera images are key for the self-calibration process, and it is noted that images from the cameras can indeed be used again in the application of the imaging equation in the subsequent stereo-PIV method in order to image flow conditions in a gas, or a fluid, with the aid of particles, which is to say to perform a PIV-method. Specifically the claim further states:

applying said imaging equation during a stereo PIV procedure on flowing particles of the visualized flow.

The Examiner's detailed rejection based on the McDowell reference is next addressed. The Examiner is of the opinion that performing the self-calibration process by determining the imaging equation is apparent from column 7, line 47 to column 8, line 30. This is based on the background that a stereo-PIV method is to be subsequently performed. In this respect, we also refer to column 2, lines 42 to 48. It has elsewhere been clearly shown that the descriptions provided from line 47 of column 7 to line 30 in column 8, do not in fact demonstrate that an imaging equation is determined for the purpose of self-calibration. It shall be emphasized again that the explanations provided in this respect in the U.S. patent specification of the all relate to the calibration using a calibration plate.

It is further called to the Examiner's attention that the self-calibration process, as it is described as the subject matter of the presently claimed invention, is performed prior to the actual stereo-PIV method and performed after the volume calibration using a calibration plate. This means that greater accuracy is achieved during the subsequent execution of the stereo-PIV method.

McDowell also recognizes the problem that, while a calibration can be conducted with the aid of a calibration plate, this calibration is very imprecise. As differs from the presently claimed invention, McDowell does not propose determining the imaging equation for calibration in the same manner as the subject

matter of the invention as explained in the claim, but rather McDowell proposes that a calibration plate be arranged in several, for example three, positions in a volume, or a space, so that both cameras can simultaneously capture the calibration points on the calibration plate. In this connection, reference shall be made to the description in column 8, starting at line 34, which reads as follows, particularly starting on line 34:

> The technique is based on using several, for example, three, parallel calibration planes placed inside a volume or chamber, so that both cameras can view the calibration points simultaneously.

This makes it clear that an increase in the accuracy of the PIV method certainly does not occur through a calibration by determination of the imaging equation, but rather McDowell proposes the use of a calibration plate in several planes in a space or volume in order to increase accuracy. Reference is made, in the first paragraph of page 4 of the Office Action, to column 2, line 56 to column 3, line 2, the descriptions provided in the McDowell specification relate exclusively to the execution of the 3DPTV PIV method. The description provided there is in no way related to the calibration.

The Examiner further cites the McDowell reference at column 7, lines 14 to 46 stating that the following is shown:

> taking first and second images using respectively first and second camera of the two cameras, the first and second images respectively having corresponding interrogation areas (col. 7, lines 14-46);

What is described in the cited portion of the McDowell reference is nothing other than a triangulation method – as we have already explained elsewhere. No indication of any cross-correlation can be found there.

Further cited by the Examiner is column 3, lines 27 to 39, of the McDowell reference, for allegedly teaching:

> determining point correspondences between the two cameras by measuring a displacement of respective interrogation areas in the first and second images using optical cross-correlation (col. 3, lines 27-39);

The remarks set forth there likewise refer solely to the PIV method and have nothing to do with the calibration. For example, line 35 of column 3 reads as follows:

> The present invention collects quantitative, three-dimensional flow data from the optically transparent fluid having tracer particles to thereby provide three-dimensional velocities at a plurality of points.

This is no more than a paraphrasing of the 3DPTV method.

Further related in the Office Action is that the McDowell reportedly sets forth in column 7, lines 49 to 52, the following:

> determining the imaging equation by means of an approximation method, using known internal and external camera parameters and the point correspondences and the displacement of respective interrogation areas (col. 7, lines 49-52);

It is respectfully called to the Examiner's attention that the entire self-calibration method, which is the subject matter of claim 1, serves exclusively for calibration

purposes, specifically by way of determination of the imaging equation. If, in this context, we look at the description in the McDowell reference, starting on line 49 of column 7, we find that what is described there takes place after the actual calibration. Column 7, line 50 reads as follows:

> ... so that during camera operation <u>after</u> the calibration procedure is completed ...

This means, that descriptions in this regard by no means relate to the calibration, but to the subsequent execution of the PIV method. In this context, column 7, line 53 reads as follows:

> ... of a tracer particle entrained in the flow are determined with only its pixel positions on the cameras.

This means that the manner in which the flow conditions of a gas or fluid in a space are determined has already been described here. While McDowell teaches the simultaneous recording of two camera images, it is always done based on the background of the PIV method.

Thus, it is respectfully submitted that the rejected claims 1-6, 9 and 10 are not obvious in view of the cited reference(s) for the reasons stated above. Reconsideration of the rejections of claims 1-6, 9 and 10 and their allowance are respectfully requested.

Claims 7 and 8 are rejected as obvious over the McDowell reference in view of the Meng reference under 35 U.S.C. §103(a). Claims 11 and 14 are rejected as obvious over the McDowell reference in view of the Raffel reference under 35 U.S.C. §103(a). The applicant herein respectfully traverses these rejections.

It is respectfully submitted that the proffered combination of references cannot render the rejected claims obvious because the secondary Meng and Raffel references do not provide the teaching noted above with respect to the obviousness rejection that is absent from the primary reference. Thus, the combination of prior art references fails to teach or suggest all the claim limitations. Therefore, reconsideration of the rejections of claims 7, 8, 11 and 14 and their allowance are respectfully requested.

REQUEST FOR EXTENSION OF TIME

Applicant respectfully requests a one month extension of time for responding to the Office Action. Please charge the fee of $65.00 for the extension of time to Deposit Account No. 10-1250.

If there is any discrepancy between the fee(s) due and the fee payment authorized in the Credit Card Payment Form PTO-2038 or the Form PTO-2038 is missing or fee payment via the Form PTO-2038 cannot be processed, the USPTO is hereby authorized to charge any fee(s) or fee(s) deficiency or credit any excess payment to Deposit Account No. 10-1250.

In light of the foregoing, the application is now believed to be in proper form for allowance of all claims and notice to that effect is earnestly solicited.

Respectfully submitted,
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